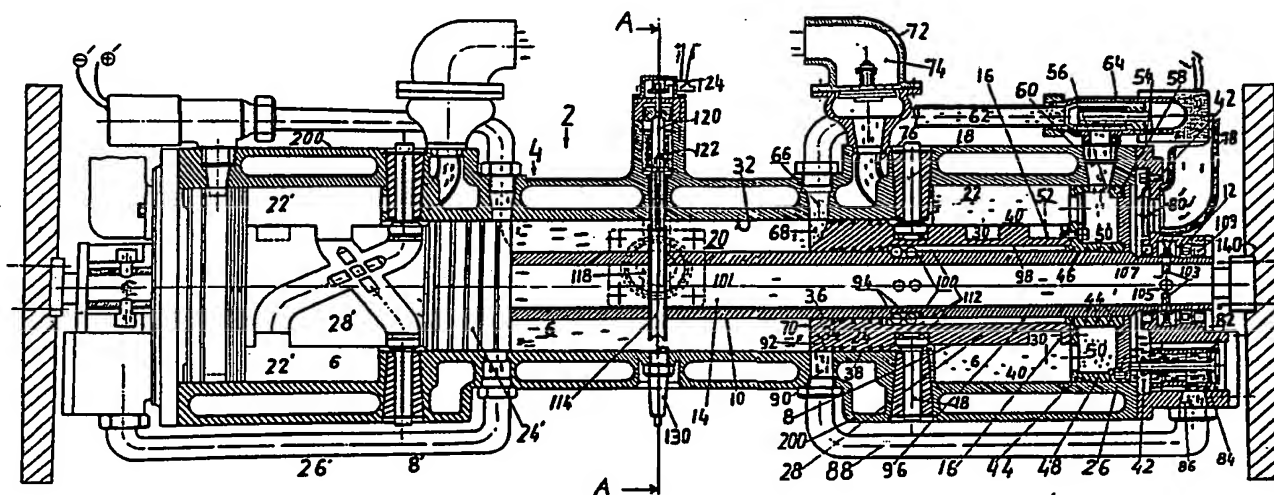




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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**(54) Title:** INTERNAL COMBUSTION ROTARY PISTON ENGINE**(57) Abstract**

A two stroke engine (2) comprises a housing (4), a cylinder (6), a shaft (10) rotatably supported in the housing (4) for rotation about the cylinder axis (14), a piston (8) slidably mounted on the shaft (10) whilst fixed for rotation with the shaft (10) and co-operating slidably with cylinder (6), a pair of sinusoidal tracks (16) and track engaging elements (18) arranged respectively on the piston (8) and on the housing (4) to relatively rotate the piston (8) about the cylinder axis (14) while undergoing reciprocation in the cylinder (6) to impart rotation to the shaft (10). Additionally, scavenging means for the engine (2) is provided by the piston (8) having a first piston head portion (24) and a second piston head portion (26) connected by a sleeve portion (28) for combined reciprocation in the respective cylinder portions (20) and (40) to supply compressed scavenging fluid and compressed combustion fluid from cylinder portion (40) to cylinder portion (20) where combustion takes place.

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- 1 -

INTERNAL COMBUSTION ROTARY PISTON ENGINEFIELD OF THE INVENTION

The invention relates to an internal combustion rotary piston engine, and in particular, but not exclusively to a two stroke internal combustion rotary piston engine.

BACKGROUND OF THE INVENTION

In the operation of an internal combustion engine, there are four steps that must take place: fuel and air must be introduced into a cylinder, the mixture must be compressed, it must then be burnt, and the exhaust gasses must be removed from the cylinder before introducing a fresh charge of fuel and air. In diesel engines, the fuel and air do not enter the cylinder at the same time, but the cycle of operation is nevertheless the same. There are two basic systems of accomplishing these operations, the four stroke cycle, in which one operation takes place during each passage of the piston up or down the cylinder, and the two stroke cycle in which two of the operations are accomplished in each passage of the piston.

In a four stroke cycle, the four mentioned steps require two complete reciprocations of the piston or two revolutions of an associated crank shaft. A fly wheel stores sufficient energy from a power stroke to carry the piston through the next three strokes before the next power stroke. In a two stroke cycle, a first charge of fuel and air is compressed below the piston or by some other means and then forced into the cylinder when the piston is at the bottom of its stroke; the charge is then compressed by the pistons upward motion, and ignited at the end of its compression stroke. At the end of the power stroke, a fresh charge sweeps the exhaust gasses out of the cylinder, however some of this charge is lost through the exhaust port during this sweeping. Accordingly, there is one power stroke for each reciprocation of the piston or revolution of an associated crank shaft.

The advantages of a two stroke engine over a four stroke engine are that it provides more frequent power strokes and has greater mechanical simplicity and lightness. These

- 2 -

advantages are to some extent offset by the fact that the two stroke engine wastes a large portion of the charge of fuel and air admitted into the cylinder. If the charge is of the same size as would be required by a comparable four stroke engine, the two stroke engine would not sweep out exhaust gasses completely, thereby cutting down on the power developed on the next stroke since a percentage of the charge includes burnt gases from the previous cycle. In addition the power stroke is shorter, since the exhaust gasses are expelled during part of the down stroke. A further disadvantage of the two stroke engine is that of lubrication. In a four stroke engine, oil stored in a crank case splashes up onto the cylinder walls to lubricate the piston. However such a system cannot be used in two stroke engines as oil splashed onto the cylinder would be carried out with the exhaust gasses eventually leaving the piston unlubricated. This is overcome by mixing lubricating oil with the fuel. However, this leads to smoky exhaust fumes and fouling of the engine by partially burnt oil.

For the above reasons, the two stroke cycle is preferred for small engines where lightness and simplicity are more important than the problems of highly polluted exhaust and the necessity of mixing lubricating oil with fuel, for example engines for lawn mowers, motor cycles, and tools such as chain saws and brush cutters. The four stroke cycle is favoured for higher powered engines, for example, in motor vehicles and boats where several pistons are attached to a crank shaft providing more power strokes per turn.

#### SUMMARY OF THE INVENTION

It is an object of the present invention to provide an internal combustion engine which attempts to alleviate at least one of the disadvantages in the above described prior art.

According to the present invention there is provided an internal combustion rotary piston engine comprising:

- a housing defining a cylinder;
- a shaft supported co-axially in said cylinder for rotation about a longitudinal axis of said shaft;

- 3 -

a piston mounted for reciprocation in said cylinder and arranged to slidably move along a length of said shaft during a power stroke of said engine; and,

means for constraining said piston to rotate about  
5 said axis during said sliding movement along said shaft and wherein said shaft is adapted to rotate with said piston about said axis, whereby, in use, said sliding movement of said piston imparts torque to said shaft.

Preferably said cylinder comprises first and second  
10 chambers and said piston, during one complete cycle of reciprocation of said piston, operates to sequentially induct a cleaning fluid into said second chamber and compress said cleaning fluid for purging said first chamber.

Preferably during said cycle said piston also  
15 operates to sequentially induct a combustion fluid into said second chamber and compress said combustion fluid for combustion in said first chamber.

Preferably said piston comprises a first head for reciprocation in said first chamber and a second head for  
20 reciprocation in said second chamber, said second head operable to induct said cleaning fluid and said combustion fluid into said second chamber.

Preferably, said cleaning fluid and said combustion fluid are inducted into said second chamber on opposite sides  
25 of said second head.

Preferably said second head comprises a storage chamber for storing a volume of compressed cleaning fluid during a portion of said cycle.

Preferably said storage chamber includes a first  
30 valve for allowing ingress of the cleaning fluid as said second head compresses said cleaning fluid, and a second valve for allowing egress of said compressed fluid.

Preferably said second valve comprises a first passage formed in said storage chamber and opening onto a  
35 circumferential surface of said cylinder, and a second passage formed in said housing and communicating with said first chamber, wherein, said first and second passages are arranged

- 4 -

to register with each other for a first predetermined period in said cycle.

Preferably said engine includes a third valve comprising a third passage communicating between said second  
5 passage and said first chamber, said third passage opening onto a circumferential wall of said cylinder and said first head, wherein said first head is arranged to open said third passage during said first predetermined period and to seal said third  
10 passage during the remaining period of said cycle.

Preferably said first head is provided with a first cut-out extending between a circumferential surface of the first head and a top surface of said first head, wherein, said first cut-out is arranged to register with said third passage during said first predetermined period to allow said compressed  
15 cleaning fluid to flow into said first chamber.

Preferably delivery of said compressed combustion fluid from said second chamber to said first chamber is effected by a fourth valve comprising a fourth passage formed in said cylinder communicating between said first and second  
20 chambers and said first piston head, wherein, said first piston head is arranged to open said third passage during a second predetermined period of said cycle occurring after the first period of said cycle and to seal said fourth passage during the remaining period of said cycle.

Preferably said first head is provided with a second cut-out extending between said circumferential surface and said top surface of the first head and circumferentially spaced from said first cut-out, wherein, said second cut-out is arranged to register with said fourth passage during said second period  
25 in said cycle.

Preferably a complete cycle of reciprocating of said engine comprises said power stroke in which a fuel comprising said combustion fluid is combusted and a return stroke during which combusted fuel is exhausted, wherein, during said power  
35 stroke said piston rotates about said axis by an angle X, where X is greater than  $180^\circ$  and less than  $360^\circ$  and during said return stroke said piston rotates through an angle Y, where Y equals  $360^\circ$  minus X.

- 5 -

Preferably X is greater than or equal to  $270^{\circ}$  and less than  $360^{\circ}$ .

Preferably X is in the order of  $270^{\circ}$ .

Preferably said constraining means comprises an  
5 endless track provided on one of said piston and said cylinder extending about said axis, and an element mounted on the other of said piston and said cylinder for engaging said track.

Preferably said element comprises a bearing received within said track for rolling contact with said track.

10 Preferably said internal combustion engine further comprises a second piston slidably mounted on said shaft and fixed for rotation with said shaft about said axis, wherein, said pistons are arranged to slide along said shaft in mutually opposite directions and to rotate in the same direction during  
15 a cycle of reciprocation of said engine.

Preferably said cylinder comprises a third chamber and said second piston comprises a first head for reciprocation in said third chamber and wherein said first and second pistons reciprocate in synchronism.

20 Preferably the displacement of said second and third chambers is greater than that of the first chamber.

Preferably said shaft includes an axial passage for flow of a lubricating fluid therethrough for lubrication and cooling of said engine.

## 25 BRIEF DESCRIPTION OF THE DRAWINGS

An embodiment of the invention will now be described by way of example only, with reference to the accompanying drawings in which;

Figure 1 is a sectional view of a first embodiment  
30 of the internal combustion rotary piston engine at the end of a first stroke;

Figures 2 is a sectional view of the internal combustion rotary piston engine illustrated in Figure 1, with the engine shown at the end of a second stroke;

35 Figure 3 is a cross sectional view along Section A-A of Figure 1;

- 6 -

Figure 4 is a development of a skirt of a piston used in the internal combustion rotary piston engine;

Figures 5 is a sectional view of a second embodiment of the internal combustion rotary piston engine at the end of  
5 a first stroke;

Figure 6 is a cross section view along section BB of Figure 5;

Figure 7 is an end view of an engine incorporating two of the internal combustion rotary piston engines of Figures  
10 1 or 5;

Figure 8 is an end view of an engine incorporating three of the internal combustion rotary piston engines of Figures 1 or 5; and,

Figure 9 is an end view of an engine incorporating  
15 four of the internal combustion rotary piston engines of Figures 1 or 5.

#### DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to the accompanying drawings, in particular Figures 1 and 2, it can be seen that the internal combustion  
20 engine 2 comprises a housing 4 defining a cylinder 6. A first piston 8 is mounted for reciprocation in the cylinder 6. A shaft 10 is supported co-axially in the cylinder 6 by bearings 12 for rotation about a longitudinal axis 14 of the shaft 10. The first piston 8 is slidably mounted on the shaft 10 and  
25 fixed for rotation with the shaft 10 about the axis 14. Also included is means, in the form of endless tracks 16 (refer Fig. 4) formed in piston 8 and track engaging elements 18, for constraining the piston 8 to rotate about the axis 14 as it slides along the shaft 10, so that, in use, reciprocation of  
30 the piston 8 imparts torque to the shaft 10.

The cylinder 6 includes integral first and second chambers 20, 22. The piston 8 comprises first and second heads 24 and 26 respectively which are spaced by a skirt 28 depending from the first head 24. The endless tracks 16 is formed as a  
35 channels on a surface 30 of the skirt 28 adjacent the circumferential surface 32 of the cylinder 6. The first head 24 reciprocates in first chamber 20 and effectively seals the



- 7 -

first chamber 20 from the second chamber 22. The sealing is achieved by way of conventional piston rings 34 residing in circular grooves formed in both inner and outer circumferential surfaces 36, 38 respectively of the first head 24.

5           The second head 26 reciprocates in the second chamber 22 and divides the second chamber 22 into sub spaces 40 and 42. The sub spaces 40 and 42 have respective volumes which vary in accordance with the position of the second head 26 within the second chamber 22. Piston rings 44 which reside in circular  
10 grooves formed in the inner and outer circumferential surfaces 46 and 48 respectively of the second head 26 effectively seal the first subspace 40 and the second subspace 42.

          The second head 26 includes a storage chamber 50 for storing a volume of compressed cleaning gas in the form of  
15 compressed air during a portion of a cycle of reciprocation of the engine, as will be described hereinafter. The storage chamber 50 is provided with a one way valve 52 which operates to allow the ingress of air into the storage chamber 50 during a return stroke of the piston 8 but prevents the escape of air  
20 during a power stroke of the piston 8.

          A second valve 54 is provided to allow the egress of compressed air from the storage chamber 50 during a subsequent portion of the cycle of the engine. The second valve 54 includes a passageway 56 formed in a circumferential wall 58  
25 of the second head 26, and a further passageway 60 formed in the housing 4. Passageway 60 communicates with the first chamber 20 via a conduit 62. A solenoid valve 64 is selectively operated to open or close the conduit 62 for communication with the passageway 60. The passageways 56 and  
30 60 are arranged to register with each other during a pre-determined period of the cycle of the engine. During this time compressed air within the storage chamber 50 can flow into the conduit 62 provided it is opened by the solenoid valve 64.

          An end of the conduit 62 opposite the solenoid valve  
35 64 is connected to the housing 4 and communicates, via a passageway 66 formed in housing 4, with the first chamber 20. The passageway 66 is selectively opened and closed by the outer circumferential surface 38 of the first head 24 which operates

- 8 -

as a rotary valve. Specifically, the first head 24 is provided with a cut-out 68 extending between the circumferential surface 38 and a top surface 70 of the first head 24. The cut out 68 is arranged to register with the passageway 66 at substantially the same time as passageway 56 registers with passageway 60 and solenoid valve 64 opens conduit 62. This allows compressed air in the storage chamber 50 to flow into the first chamber 20.

Fresh air is supplied to the second chamber 22 via an air intake manifold 72 which communicates via a one way valve 74 with an air intake conduit 76 which in turn opens into the sub space 40 of the second chamber 22.

A combustion fluid, in the form of a fuel and fresh air mixture, is supplied to the subspace 42 through a manifold 78 which is opened and closed by a one way valve 80. When the piston 6 is travelling in its return stroke (as illustrated in Figure 2) a partial vacuum is created in the sub space 42 forming a pressure differential across, and subsequent opening, the one way valve 80. This in turn allows the fuel and air mixture to enter the sub space 42. During this part of the cycle of the engine the solenoid valve 64 is operated to close conduit 62 thereby preventing any significant loss of fuel air mixture through the passageway 60.

The term "combustion fluid" is used in general to denote any fluid which is either combustible or aids in the combustion of a combustible fluid, for example, petrol, diesel, alcohol, oxidant, air or a mixture thereof.

The sub space 42 is provided with an outlet 82 which is opened and closed by a spring valve 84. The outlet 82 communicates, via a passageway 86 formed in the housing 4, with one end of a conduit 88. The opposite end of conduit 88 leads into a passageway 90 formed in the housing 4 that communicates with the first chamber 20. The passageway 90 is opened and closed by the first head 24 which operates as a rotary valve. In particular, the first head 24 is provided with a second cut-out 92 (shown in phantom) that extends between the top surface 70 and peripheral surface 38 of the first head 24. The cut-out 92 is arranged to register with the passageway 90 at the same

- 9 -

time as spring operated valve 84 is opened so that fuel and air mixture in the sub space 42 can flow into the first chamber 20.

The volume or displacement of the second chamber 22 is equal or preferably greater than that of the first chamber 20. Accordingly, air or the fuel and air mixture when transferred from chamber 22 remains under greater pressure than atmospheric pressure.

Circumferentially spaced about the shaft 10 are four recesses 94. Four longitudinal slots 96 are also formed about an inner circumferential surface 98 of the skirt 28. As more clearly seen in Figure 3, the shaft 10 and piston 6 are mechanically coupled by pairs of ball bearings 100 which are accommodated between corresponding recesses 94 and slots 96. This coupling arrangement allows the piston 8 to slide axially along the shaft 10 while simultaneously fixing or locking the piston 8 for rotation with the shaft 10 about the longitudinal axis 14.

Referring to Figure 4 it can be seen that each endless track 16 formed in the skirt 28 is in the form of a rectangular section channel having opposing side walls 102, 104 and a bottom wall 106. Each track 16 is sinusoidal in development. The track engaging elements 18 are received in respective tracks 16 at diametrically opposed locations. Each element 18 includes a bearing 108 for rolling contact with the side walls 102, 104 of corresponding track 16. Each element 18 is fixed with respect to the housing 4 so that cooperation between elements 18 and the corresponding tracks 16 cause the piston to rotate about axis 14 upon axial movement along the shaft 10. Furthermore, as the piston 8 is fixed for rotation with the shaft 10 the rotation of the piston 8 causes corresponding rotation of the shaft 10 about axis 14.

Each track 16 comprises one sinusoidal cycle which has the effect of causing the piston 8 to rotate 360° during one complete cycle of the engine 2. The tracks 16 are configured so that during a power stroke of the engine the piston 8 rotates through 270°, and during a return stroke the piston rotates through 90°.

- 10 -

At the locations where the tracks 16 intersect, guides in the form of protrusions 110 extending from bottom walls 106 are provided to ensure that each element 18 remains in its respective track. The protrusions 110 pass between  
5 spaced apart legs 112 extending from one side of roller 108 toward the bottom wall 106.

A cam 114 (refer Figs. 1, 2 and 3) is coaxially mounted on the shaft 10 in the first chamber 20. The cam 114 operates the solenoid valve 64 and an exhaust valve 116. The  
10 exhaust valve 116 opens and closes an exhaust port 118 formed in the first chamber 20. A cam follower 120 is biased into contact with the cam 114 by means of a coil spring 122. The cam follower 120 in turn operates, an electric switch 124 for selectively energising and de-energising the solenoid valve 64,  
15 and a rocker arm 126 which operates the exhaust valve 116. The cam 114 and cam follower 120 cooperate so as to open both solenoid valve 64 and exhaust valve 116 simultaneously. This allows compressed air from storage chamber 50 to flow into the first chamber 20 and out through exhaust port 118 to assist in  
20 clearing combusted fuel from the cylinder 6. This flow of air also aids in cooling of the engine 2.

The engine 2 further incorporates a lubrication system which also serves to assist cooling. The lubrication system (refer Fig. 2) comprises a central axial passage 101  
25 formed within the shaft 10. An end of the shaft 10 near the fly wheel 140 is provided with a number of openings 103 which communicate with a cavity 105 formed in the housing 4. The cavity is sealed on one side by sealing ring 107 and on the opposite side by sealing ring 109 adjacent bearing 12. A  
30 similar arrangement of openings, cavities and sealing rings are provided at the other end of the shaft 10. The shaft 10 is also provided with a number of transversely extending small bleed holes 111. The lubricating system also includes an oil reservoir (not shown), an oil cooler (not shown) and a pipe  
35 (not shown) providing a series connection from cavity 105 through the oil reservoir and cooler to a similar cavity formed near the other end of the shaft 10. This forms a continuous loop for the circulation of lubricating oil within the

- 11 -

passageway 101. Oil is conveyed along the passageway 101 by centrifugal force as the shaft 10 rotates. Oil is also able to lubricate the piston 8 by passing through bleed holes 111 and lubricate the bearing 12 by passing through openings 103.

5 Movement of the oil through passage 101 also assists in extracting heat from the engine and pistons. Thus, in effect, the rotating shaft act as an oil pump.

The engine 2 further comprises a second piston 8' of identical construction to piston 8. In particular, piston 8' 10 includes first and second heads 24', 26', which are spaced apart by a skirt 28' depending from the first head 24'. The first head 24' reciprocates in the first chamber 20 and second head 26' reciprocates in a third chamber 22' of the cylinder 6.

15 The second piston 8' is mounted on the shaft 10 in exactly the same manner as piston 8. Moreover, pistons 8 and 8' are arranged so as to slide along the shaft 10 in mutually opposite directions and to rotate in the same direction during a complete cycle of the engine 2.

20 The first chamber 20 functions as a combustion chamber of the engine 2. Spark plugs 138 communicate with the combustion chamber for igniting a combustion gas within the combustion chamber.

25 Water jackets 200 are provided about the housing 4 to assist in cooling the engine 2.

The operation of the above embodiment of the engine 2 will now be described with particular reference to piston 8. However, it is to be understood that the operation of the end of engine 2 incorporating piston 8' is identical.

30 The engine 2 is operated on a two stroke cycle. The first stroke is a power stroke in which fuel in the chamber 20 is ignited and forces the piston 8 away from cam 114, and a second or return stroke in which combusted fuel is exhausted and a fresh charge of fuel is inducted into the chamber 20. 35 During the power stroke piston 8 moves from top dead centre towards bottom dead centre (position shown in Figure 1) and fresh air is inducted into the chamber 40 through air intake manifold 72, one way valve 74, and air intake conduit 76.

- 12 -

Simultaneously, a fuel and air mixture in chamber 42 is compressed by the second head 26. During the return stroke (shown in Figure 2) the fuel and air mixture is inducted into the subspace 42 through fuel intake manifold 78 and one way valve 80. Simultaneously, fresh air previously inducted into the chamber 40 is compressed by the second head 26 and enters the storage chamber 50 through one way valve 52 which is now open.

When the piston 8 is at bottom dead centre (illustrated in Figure 1) cam 114 forces the cam follower 120 upwardly against the bias of coil spring 122. The cam follower 120 then operates electric switch 124 to open the solenoid valve 64 and the rocker arm 126 to open the exhaust valve 116. At or near bottom dead centre, passageway 56 registers with passageway 60 and passageway 66 registers with cut-out 68. Therefore, compressed air in chamber 50 can flow into the combustion chamber 20 through conduit 62 to assist in exhausting combusted fuel through exhaust port 118.

The second head 26 also operates the valve 84 to open the outlet 82 allowing the passage of compressed fuel and air from subspace 42 into the conduit 88. However the fuel is prevented from entering the chamber 20 as passageway 90 is presently closed by the first head 24.

As the cycle of operation continues the piston 8 begins to travel on its return stroke toward the cam 114 and is caused to rotate by virtue of the operation of the tracks 16 and track engaging elements 18. During the rotation of the piston 8 the second cut-out 92 is brought into registration with the passageway 90. This allows the compressed fuel residing in the conduit 88 to enter the chamber 20. Also at this point in time the cam 114 is rotated about the axis 14 allowing the cam follower 120 to be forced by spring 122 toward axis 14 so as to release rocker arm 126 and cause the exhaust valve 116 to close the exhaust port 118.

During continued motion of the piston in the return stroke the fuel and mixture in chamber 20 is further compressed between pistons 8 and 8'. As described above, during this motion of the piston, fuel and air is drawn into the subspace

- 13 -

42 and fresh air within subspace 40 is compressed and forced into the storage chamber 50 through one way valve 52.

When the piston 8 reaches top dead centre (illustrated in Figure 2) a substantial volume of the air originally inducted into the subspace 40 has been compressed and forced into the storage space 50. However, a small volume of air flows into the space between the skirt 28 and the circumferential surface 32 of the cylinder 6 up to an end of the first head 24 opposite the top surface 70. This air provides additional cooling to the engine 2. It is to be noted that the air in the space cannot return to the second chamber 22 through conduits 62 or 88 as valves 64 and 84 are closed. During the period shortly before or after reaching the top dead centre, sparks are created in the combustion chamber between the pistons 8 and 8' by the spark plugs 138. This ignites the fuel and air mixture within this space driving the pistons 8 and 8' apart, axially along the shaft 10 away from the cam 114. As the piston 8 is driven in this direction it is also caused to rotate by virtue of the cooperation between the track engaging elements 18 and the tracks 16. The rotation of the piston 8 causes corresponding rotation of the shaft 10 about the axis 14 and thereby imparts torque to the shaft 10. The torque imparted to the shaft drives a fly wheel 140 connected to an end of the shaft 10.

As the piston 8 moves towards bottom dead centre during its power stroke the fuel and air mixture in the second subspace 42 is compressed by the second head 26. Simultaneously, air is drawn into the first subspace 40 through air intake manifold 72, one way valve 74 and air intake conduit 76. The one way valve 52 is closed preventing air from entering the storage chamber 50.

After reaching bottom dead centre the piston 8 is returned toward top dead centre by energy stored in the fly wheel 140 which rotates shaft 10 and consequently rotates the piston 8. Due to the configuration of the tracks 16 and the engagement of the tracks 16 with the engaging elements 18 the piston 8 is rotated about axis 14 as it travels axially along shaft 10 towards top dead centre. It is to be understood that

- 14 -

this occurs without a change in direction of rotation of the shaft 10 or piston 8.

A second embodiment of the engine is illustrated in Figure 5 in which like reference numbers denote identical features. There are three main differences between the first and second embodiments. The solenoid valve 64 of the first embodiment is replaced with a spring operated valve 64A which is operated by a cam surface 142 on the fly wheel 140. The spring valve 84 which in the first embodiment is operated by the second head 26 is replaced with spring valve 84A which is operated by a cam surface 144 on the fly wheel 140. Finally, the exhaust valve 116 and associated cam 114, cam follower 120, and rocker arm 126 are replaced by a rotary exhaust valve 116A.

The cam surfaces 142, 144 can be formed as separate arcuate elements that can be demountably connected to the fly wheel 140. In this way the timing of the valves 64A and 84A can be easily varied by attaching cam elements of predetermined lengths and profiles to the fly wheel 140.

The rotary valve 116A comprises an annular plate 148 (refer Fig. 6) coaxially connected to the shaft 10 and extending radially thereof. A plurality of apertures 150 is formed in a plate 148 to allow the free flow of gases between opposite sides of the plate 148. The annular plate 148 terminates in a cylindrical flange 152 having a longitudinal axis coaxial with axis 14. Sealing rings 154 are provided in surface 156 of the flange 152 adjacent the circumferential wall 32 of the cylinder 6. The rings 154 create a seal between the walls 156 and 32. An aperture 158 is formed in the flange 152. The aperture 158 registers with exhaust port 118 once during each complete rotation of shaft 10 about axis 14. During this period gases within the chamber 20 can be exhausted through the aperture 158 and exhaust port 118.

In all other respects the working of engine 2 illustrated in Figure 5 is identical to that of the first embodiment illustrated in Figures 1, 2 and 3.

As illustrated in Figures 7, 8 and 9, several engines 2 according to the invention can be coupled to a common output shaft 160 for combining the power output of the engines 2. The



- 15 -

coupling of the engines 2 to the common output shaft 160 can be readily achieved by connecting a gear 162 to the respective shafts 10 of each engine 2 and disposing the engines 2 about the common output shaft 160 in a manner so that each gear 162  
5 meshes with a gear 164 attached to the output shaft 160.

Theoretical calculations have shown that for an engine 2 having a displacement of 1870 cubic centimetres the power output of 190hp to 195hp at 5000rpm.

It will be readily apparent that the above described  
10 embodiments have numerous advantages over conventional two stroke and four stroke engines. Significantly, the power stroke of each piston results in a  $270^\circ$  rotation of the shaft 10 and energy is only required from the fly wheel 140 to rotate the shaft 10 through a further  $90^\circ$  to return the piston to top  
15 dead centre. This provides numerous advantages over conventional piston engines where a crank shaft is rotated through  $180^\circ$  in the power stroke and utilises energy from a fly wheel to rotate through a further  $180^\circ$  in a return stroke. The extended duration of the power stroke in the present  
20 embodiments is more efficient as it allows torque to be imparted to the fly wheel for a greater period of the cycle of the engine and allows increased burning time to reduce the percentages of noxious exhaust fumes such as carbon monoxide, carbon dioxide, as well as unburnt fuel.

25 It will be noted that in a conventional two stroke engine the combusted fuel is swept out of the cylinder through an exhaust port by an incoming fresh charge of fuel and air. Accordingly, a portion of the fresh charge can be lost through the exhaust port. Also a portion of the combusted fuel remains  
30 in the cylinder and is mixed with the fresh charge. However, both of these problems are substantially overcome by the present embodiments because compressed fresh air is used to purge or sweep clean the combustion chamber before the next fresh charge of fuel and air is admitted into the combustion  
35 chamber. Thus, substantially none of the fresh charge is exhausted and substantially no exhaust gases are mixed with the fresh charge.

- 16 -

Furthermore, the forces imparted on the pistons are substantially axial so that there is no significant side thrust on the piston as occurs with conventional reciprocating piston engines. Due to the nature of the connection between each piston and the housing, the momentum gained by the piston in its power stroke is used to assist movement of the piston in its return stroke. The benefit of the momentum is not lost when the piston changes direction of linear travel as occurs with conventional piston engines. Furthermore, the rotating pistons function as fly wheels to conserve momentum of the shaft 10 which in turn allows for the use of smaller fly wheels as would otherwise be the case.

The displacement of the engine 2 is dependent on the difference between the volume of the cylinder 6 and the diameter of the shaft 10. Thus by simply replacing shaft 10 with another shaft of smaller or greater diameter the displacement can be correspondingly increased or decreased.

Now that embodiments of the invention have been described in detail it will be apparent to those skilled in the relevant arts that numerous modifications and variations may be made without departing from the basic inventive concept.

For example, in the present embodiment, the engines 2 are shown as being normally aspirated, that is, fuel and air pre-mixed prior to entering the combustion chamber 20. However, engine 2 can also be operated with a fuel injection system in which fuel is injected into the combustion chamber 20 separate from compressed air.

Although two cylinders 8 and 8' as shown in the embodiments, the engine 2 can of course operate with a single piston only. Furthermore, the cylinder 6 may be divided into two separate cylinders by a transverse wall extending between pistons 8 and 8'. In this arrangement, there would be two combustion chambers one associated with each piston. In an alternative arrangement with the cylinder 6 divided by a transverse wall, the pistons 8 and 8' can be arranged in a "push-pull" manner where, as one piston is in the power stroke of its cycle the other is in the return stroke, and visa versa.

- 17 -

Furthermore, although piston 8 is described as rotating through  $270^\circ$  in the power stroke and at  $90^\circ$  in return stroke the actual degree of rotation can be varied for different applications. It is preferable however that the  
5 degree of rotation of the piston in the power stroke be greater than that during the return stroke.

The endless tracks 16 can be made to have sectional profiles other than rectangular. For example, the tracks 16 can be in the form of a triangular or semi-circular sectional  
10 channel, or a channel having opposite side walls diverging from a common bottom wall. Furthermore, the profile of the tracks 16 may vary at or near the points of intersection. Moreover, each track 16 may have a different profile.

As an alternative to storing compressed air in  
15 storage chamber 50 in the second head 26, a separate storage chamber can be provided outside the cylinder 6. In this arrangement, air inducted into the second chamber 40 during the power stroke can be forced to and compressed in the separate storage chamber outside the cylinder 6 through a port in the  
20 second chamber 40 during the return stroke. An outlet of the separate storage chamber can communicate with valve 64 to allow passage of compressed air into the first chamber 20 in the same manner as described above with reference to storage chamber 50.

All such modifications and variations are deemed to  
25 be within the scope of the present invention, the nature of which is to be determined from the foregoing description and the appended claims.

- 18 -

## THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. An internal combustion rotary piston engine comprising:
  - a housing defining a cylinder;
  - 5 a shaft supported co-axially in said cylinder for rotation about a longitudinal axis of said shaft;
  - a piston mounted for reciprocation in said cylinder and arranged to slidably move along a length of said shaft during a power stroke of said engine; and,
  - 10 means for constraining said piston to rotate about said axis during said sliding movement along said shaft and wherein said shaft is adapted to rotate with said piston about said axis, whereby, in use, said sliding movement of said piston imparts torque to said shaft.
- 15 2. An engine according to claim 1, wherein said cylinder comprises first and second chambers and said piston, during one complete cycle of reciprocation of said piston, operates to sequentially induct cleaning fluid into said second chamber, and compress said cleaning fluid for purging said first  
20 chamber.
3. An engine according to claim 2, wherein during said cycle said piston further operates to sequentially induct a combustion fluid into said second chamber and compress said combustion fluid for combustion in said first chamber.
- 25 4. An engine according to claim 2 or 3, wherein said piston comprises a first head for reciprocation in said first chamber and a second head for reciprocation in said second chamber, said second head operatable to induct said cleaning fluid and combustion fluid into said second chamber.
- 30 5. An engine according to claim 4, wherein said cleaning fluid and said combustion fluid are inducted into said second chamber on opposite sides of said second head.

- 19 -

6. An engine according to claim 5, further comprising a storage chamber for storing a volume of cleaning fluid compressed by said second head, said storage chamber being in communication with said second chamber.
- 5 7. An engine according to claim 6, wherein said storage chamber is formed in said second head and includes a first valve for allowing ingress of the cleaning fluid as said second head compresses said cleaning fluid, and a second valve for allowing egress of said compressed fluid from said storage  
10 chamber.
8. An engine according to claim 7, wherein said second valve comprises a first passage formed in said storage chamber and opening onto a circumferential surface of said cylinder, and a second passage formed in said housing and able to  
15 communicate with said first chamber, wherein, said first and second passages are arranged to register with each other for a first predetermined period in said cycle.
9. An engine according to claim 6, wherein said storage chamber is located outside said cylinder.
- 20 10. An engine according to claim 8, further comprising a third valve including:  
a third passage adapted to communicate between said second passage and said first chamber, said third passage opening onto said circumferential surface of said cylinder;  
25 and,  
said first head; wherein, said first head is arranged to open said third passage during said first predetermined period and to seal said third passage during the remaining period of said cycle.
- 30 11. An engine according to claim 10, wherein said first head is provided with a first cut-out extending between a circumferential surface of the first head and top surface of

- 20 -

the first head, wherein, said first cut-out is arranged to register with said third passageway during said first predetermined period to allow said compressed cleaning fluid to flow into said first chamber.

- 5 12. An engine according to any one of claims 3 to 11, wherein the delivery of said compressed combustion fluid from said second chamber to said first chamber is effected by a fourth valve comprising:

10 a fourth passage formed in said cylinder communicating between said first and second chambers; and, said first head, wherein, said first head is arranged to open said fourth passage during a second predetermined period of said cycle occurring after the first period of the cycle, and to seal said fourth passage during the remaining  
15 period of the cycle.

13. An engine according to claim 12, wherein said first head is provided with a second cut-out extending between said circumferential surface of said first head and said top surface of said first head and circumferentially spaced from said first  
20 cut-out, wherein, said second cut-out is arranged to register with said fourth passage during said second period in said cycle.

14. An engine according to any one of claims 1 to 13, wherein a complete cycle of reciprocation of said engine  
25 comprises a first stroke in which a fuel comprising said combustion fluid is combusted and a second stroke during which combusted combustion fuel is exhausted, wherein, during said first stroke said piston rotates about said axis by an angle X, where X is greater than  $180^\circ$  and less than  $360^\circ$ , and during  
30 said second stroke said piston rotates through an angle Y, where Y equals  $360^\circ$  minus X.

15. An engine according to claim 14, wherein X is greater than or equal to  $270^\circ$  and less than  $360^\circ$ .

- 21 -

16. An engine according to claim 15, wherein X is in the order of 270°.

17. An engine according to any one of claims 1 to 16, wherein said constraining means comprises an endless track  
5 provided on one of said piston and said cylinder extending about said axis, and an element mounted on the other of said piston and said cylinder for engaging said track.

18. An engine according to claim 17, wherein said element comprises a bearing locatable within said track for rolling  
10 contact with said track.

19. An engine according to claim 17, further comprising a second endless track provided on said one of said piston and said cylinder and a second element mounted on said other of said piston and said cylinder for engaging said track.

20. An engine according to claim 19, wherein said endless track and said second endless track are arranged to cross at an intersection and said constraining means further includes guiding means for guiding said element and said second element to remain in said endless track and said second endless track  
15 20 respectively as said element passes through said intersection.

21. An engine according to any one of claims 1 to 20, further comprising a second piston slidably mounted on said shaft and arranged for rotation with said shaft about said axis, wherein, said pistons are arranged to slide along said  
25 shaft in mutually opposite directions and to rotate in the same direction during a cycle of reciprocation of said engine.

22. An engine according to claim 21, wherein said cylinder comprises a third chamber, and said second piston comprises a first head for reciprocation in said first chamber  
30 and a second head for reciprocation in said third chamber,

- 22 -

wherein said first and second pistons reciprocate and rotate in synchronism.

23. An engine according to any one of claims 2 to 22, wherein the displacement of said second chamber is equal or  
5 greater than that of the first chamber.

24. An engine according to claim 22, wherein the displacement of said third chamber is equal or greater than that of said first chamber.

25. An engine according to any one of claims 1 to 24,  
10 wherein said shaft includes an axial passage for flow of a lubricating fluid therethrough for lubrication and cooling of said engine.

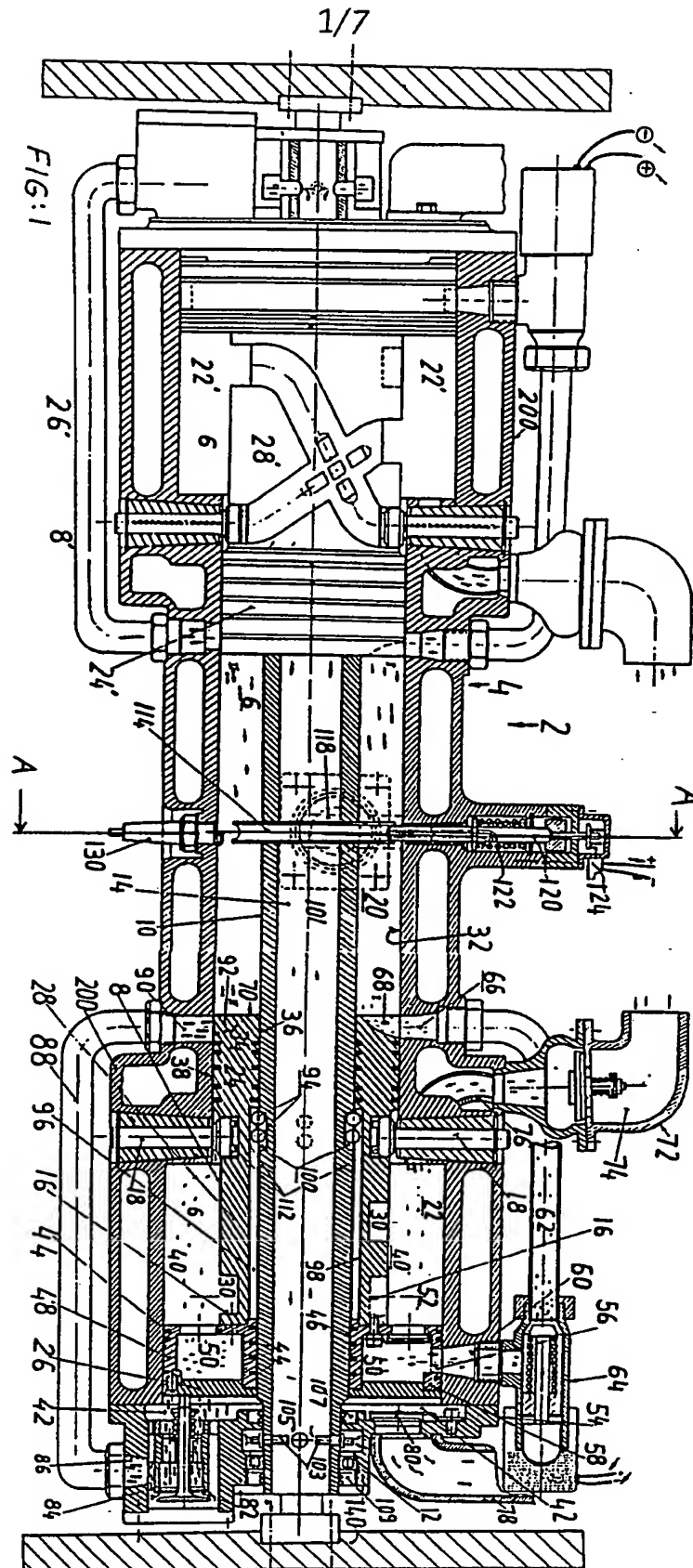
26. An ending according to claim 25, wherein said shaft, when it rotates about said axis, acts as a pump for circulating  
15 said lubricating fluid through said engine.

27. An engine according to any one of claims 2 to 26, wherein said cleaning fluid acts to internally cool said engine by transferring heat generated by said engine from between said piston and said cylinder to the external atmosphere.

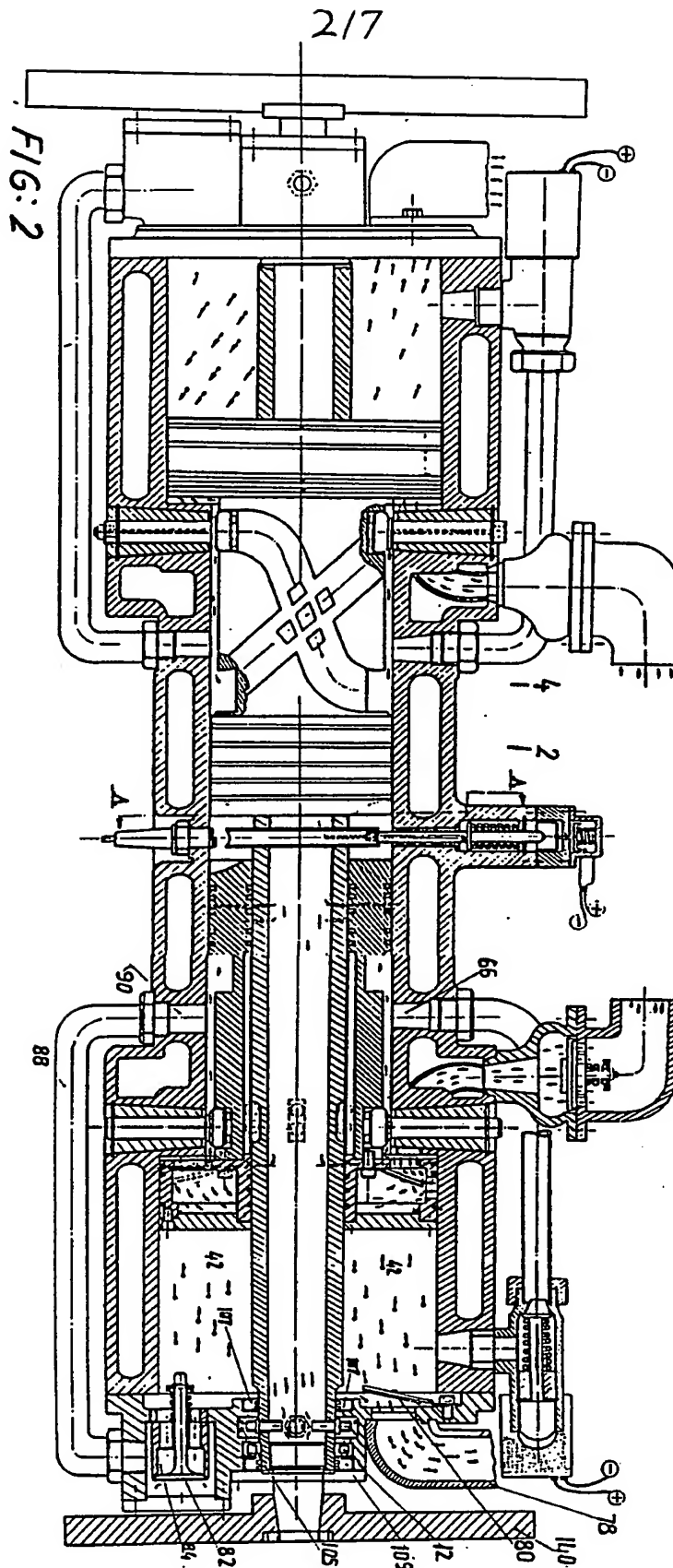
20 28. An internal combustion rotary piston engine substantially as herein described with reference to and as illustrated in any one or more of the accompanying drawings.

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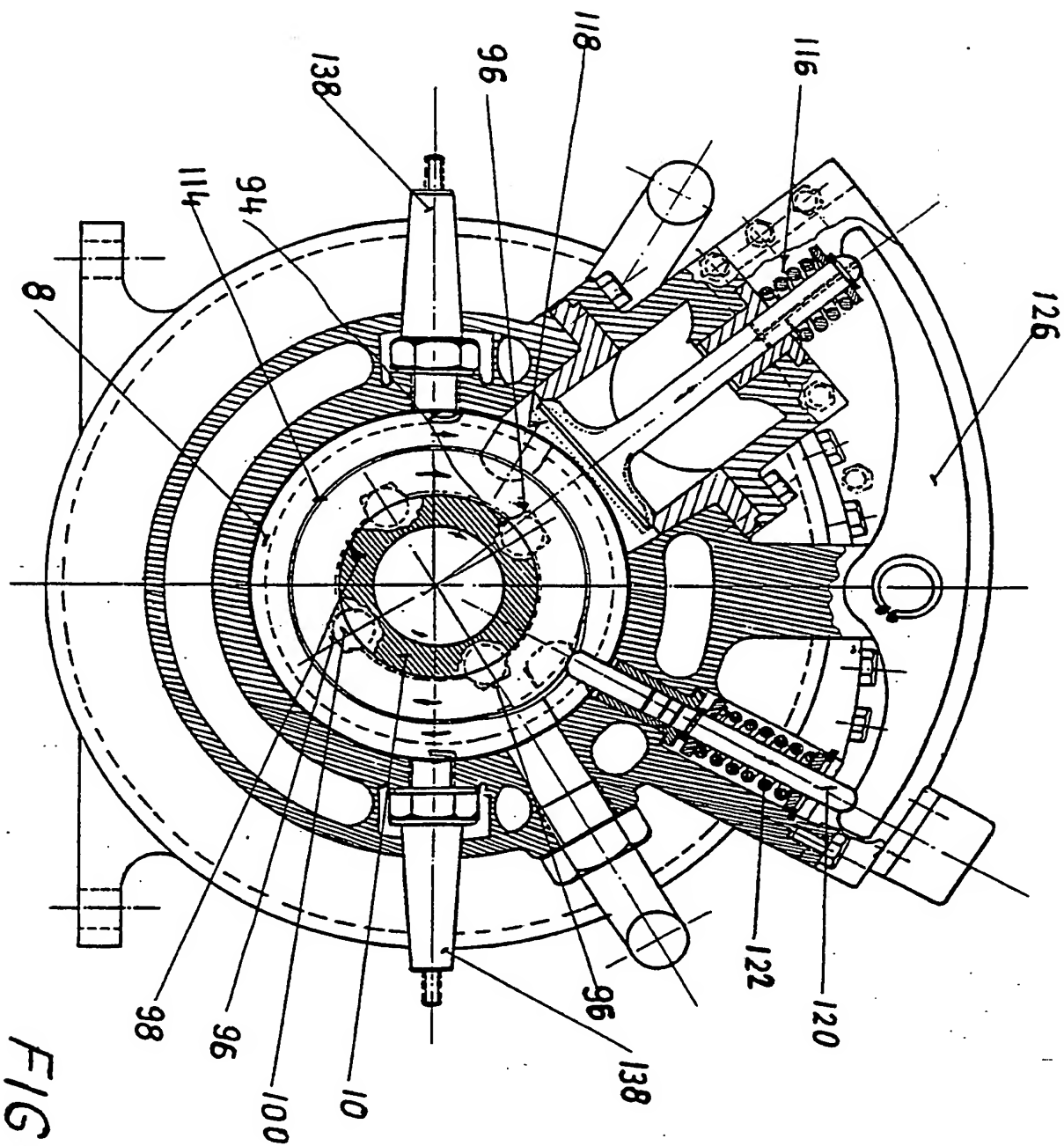
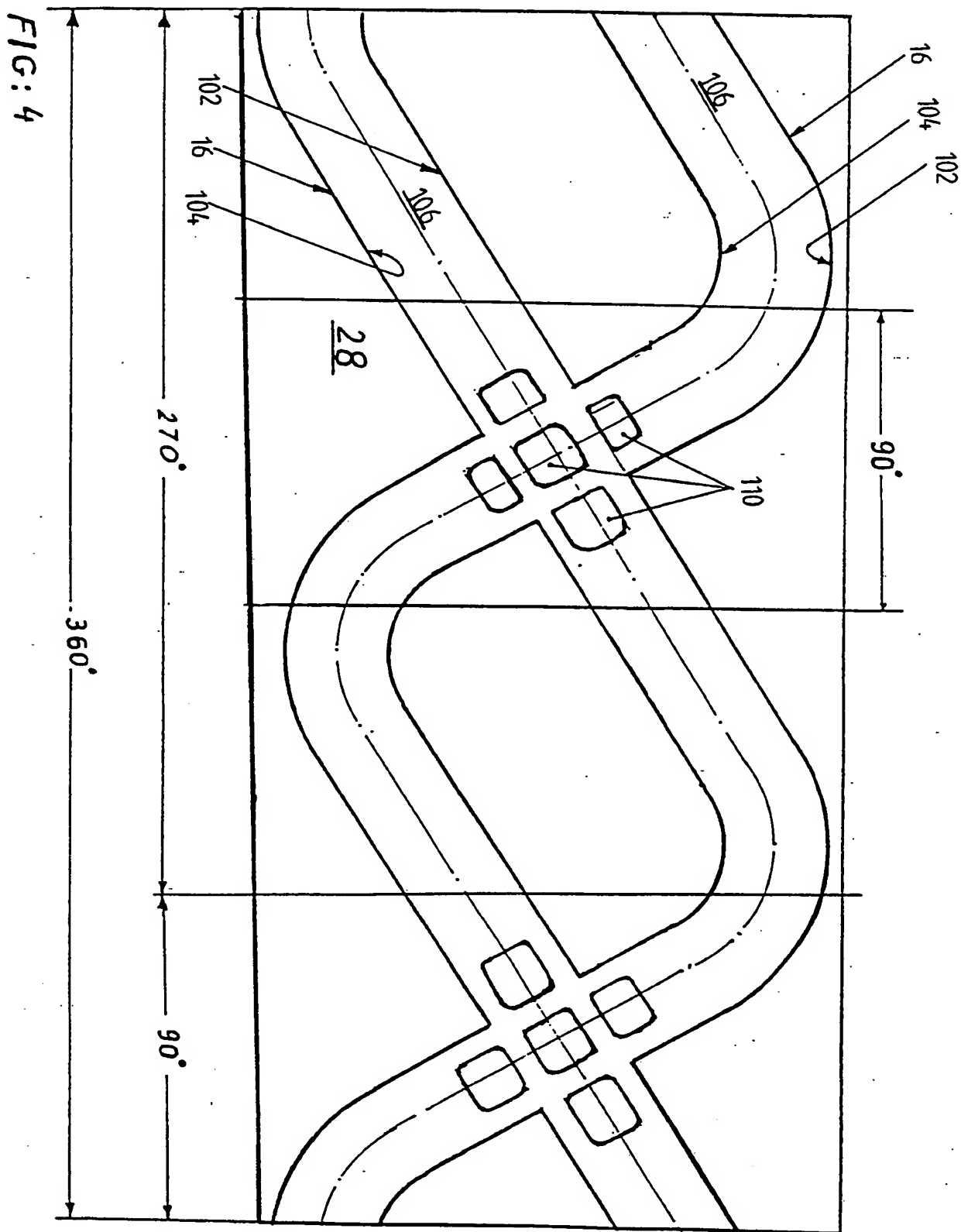
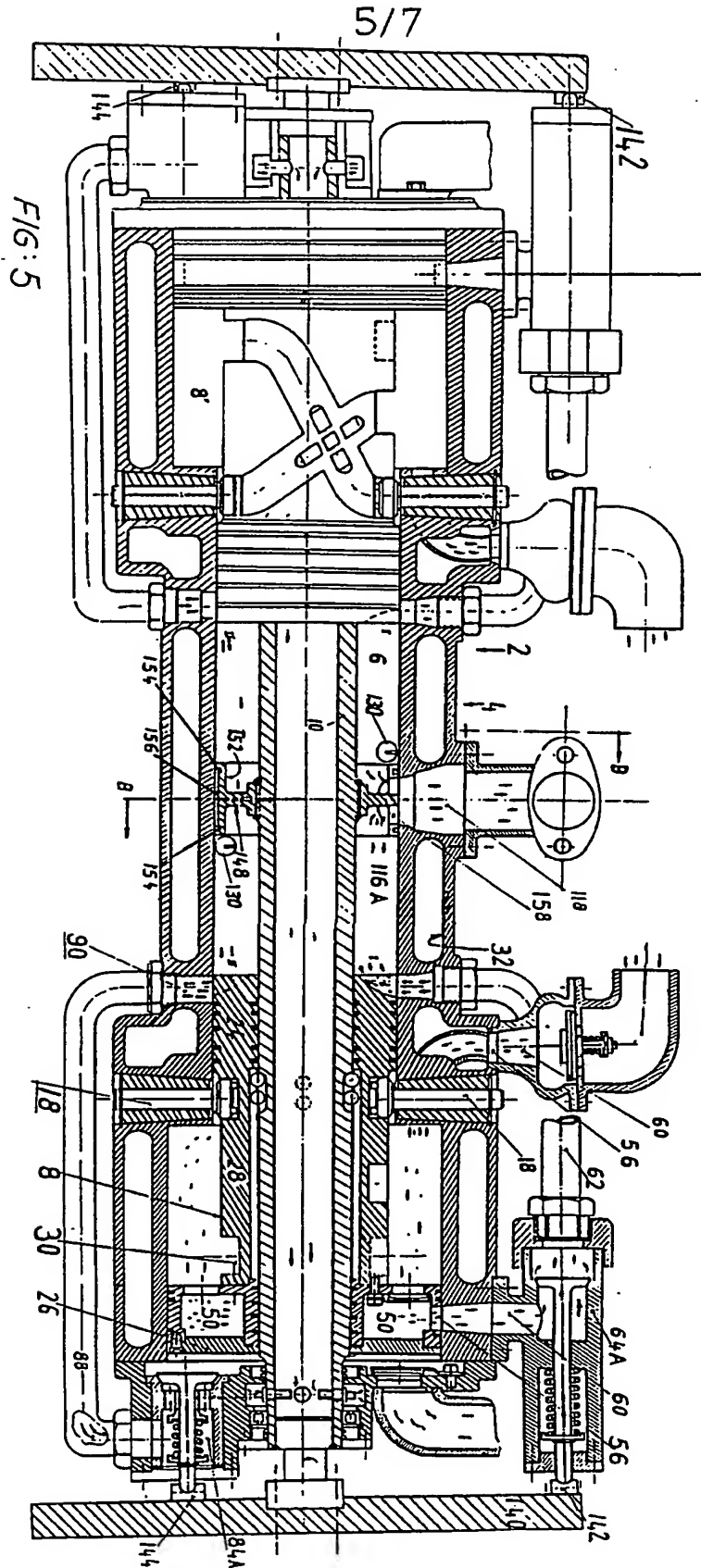


FIG:3

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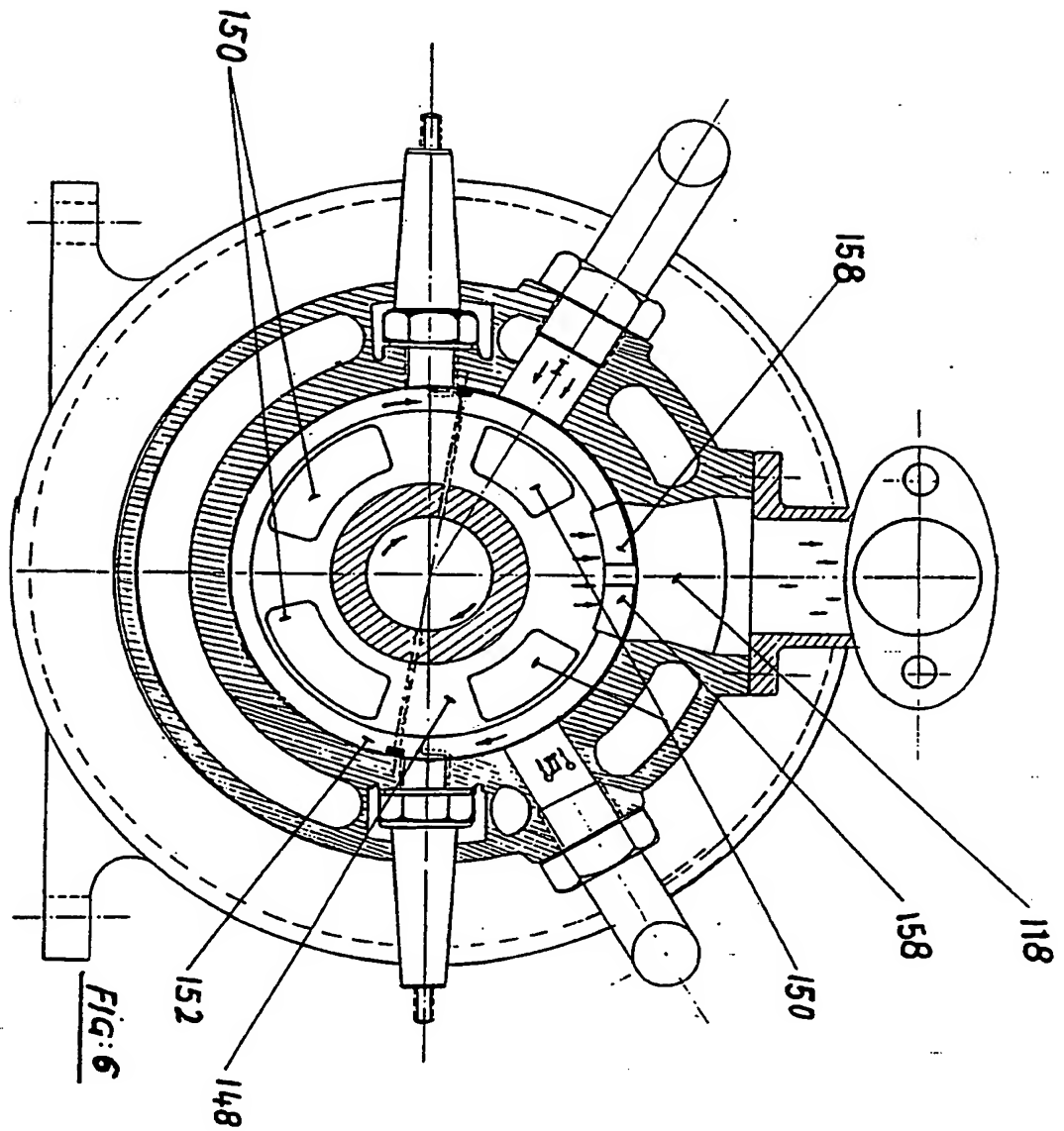


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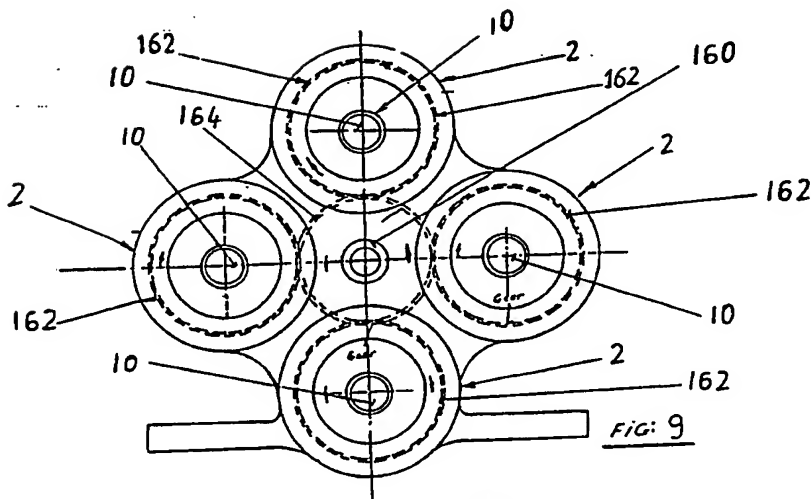
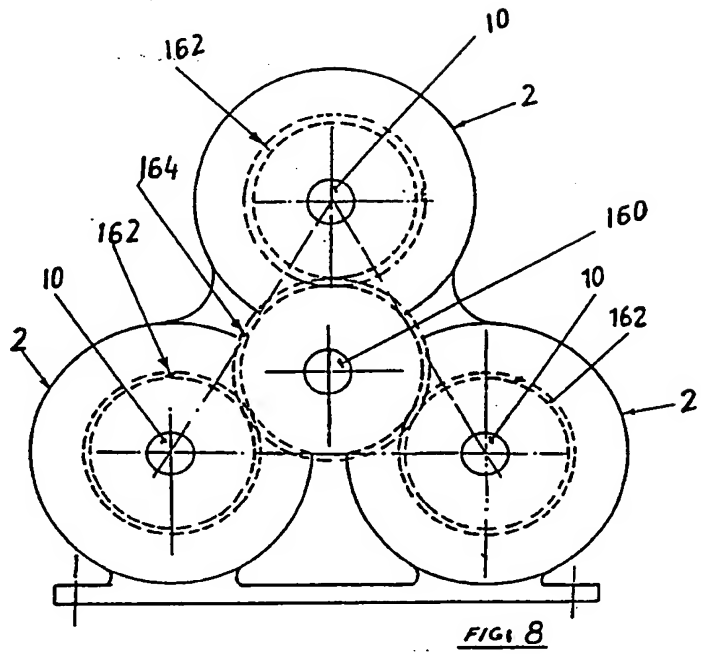
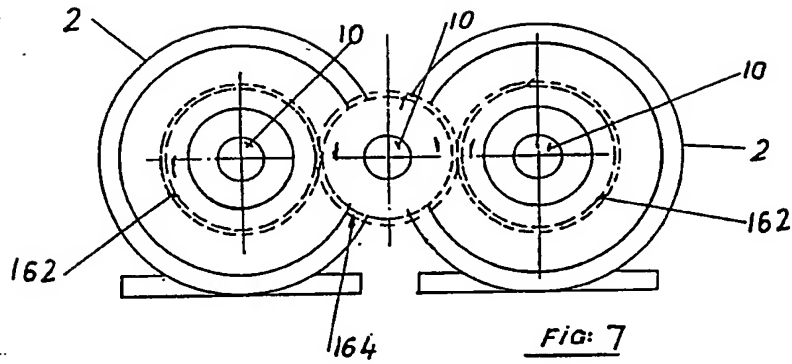
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6/7



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7/7



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<b>A. CLASSIFICATION OF SUBJECT MATTER</b> Int. Cl. <sup>5</sup> F01B 3/04, 7/04, 9/06; F02B 33/06, 33/44, 75/28, 75/32  According to International Patent Classification (IPC) or to both national classification and IPC					
<b>B. FIELDS SEARCHED</b>  Minimum documentation searched (classification system followed by classification symbols) IPC F01B 3/04, 7/04, 9/06, F02B 33/06, 33/44, 75/28, 75/32, F04B 7/06, 9/04  Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched AU : IPC as above ; Australian Classification 68.311  Electronic data base consulted during the international search (name of data base, and where practicable, search terms used) DERWENT					
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>					
Category <sup>o</sup>	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.			
X	US,A, 4974556 (ROYSE) 4 Decmeber 1990 (04.12.90) figures 1 and 2 and description, column 4, line 56 to column 8, line 57 " " " " " " " "	1-6,9,17-18,21-22, 25-27. 2-10,23			
Y	" " " " " " " "	2-10,23			
X	US,A, 2532106 (KORSGREN) 28 November 1950 (28.11.50) figures 1-3 and description, column 2, line 16 to column 7, line 33 " " " " " " " "	1,21-22 3			
Y	" " " " " " " "	3			
<div style="display: flex; justify-content: space-between;"> <div> <input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C.         </div> <div> <input checked="" type="checkbox"/> See patent family annex.         </div> </div>					
<table style="width: 100%; border: none;"> <tr> <td style="width: 33%; vertical-align: top;">           * Special categories of cited documents :            "A" document defining the general state of the art which is not considered to be of particular relevance            "E" earlier document but published on or after the international filing date            "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)            "O" document referring to an oral disclosure, use, exhibition or other means            "P" document published prior to the international filing date but later than the priority date claimed         </td> <td style="width: 33%; vertical-align: top;">           "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention            "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone            "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art            "&amp;" document member of the same patent family         </td> <td style="width: 33%;"></td> </tr> </table>			* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family	
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family				
Date of the actual completion of the international search 16 December 1992 (16.12.92)		Date of mailing of the international search report 29 JAN 1993 (29.01.93)			
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200 WODEN ACT 2606 AUSTRALIA  Facsimile No. 06 2811841		Authorized officer  C.M. WYATT Telephone No. (06) 2832538 			



C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate of the relevant passages	Relevant to Claim No.
X	DE,A, 3831451 (MIRCEA) 12 April 1990 (12.04.90) figure 9 and description, column 4	1,17-19
X	DE,A, 472564 (SHIEFFELIN) 1 March 1929 (01.03.29) figures 1-3 and description, page 1, line 55 to page 2, line 66	1,17-18,25-26
X	GB,A, 1563498 (SCHREIBER) 26 March 1980 (26.03.80) figures 1-3 and description, page 2, line 8 to line 129	1,17-18,25-26
Y	WO,A, 87/02416 (HOOPER) 23 April 1987 (23.04.87) abstract and figure 1	23
Y	WO,A, 90/12952 (MCARTHUR) 1 November 1990 (01.11.90) abstract and figures 1 and 2	2,6-8,10-11,27
Y	AU,B, 29904/30 (LANCASTER et. al) 26 March 1931 (26.03.31) column 1, line 22 to column 5, line 45 and figure 5	2-5,27
Y	DE,A, 504514 (PLAGE) 8 august 1930 (08.08.30) page 1, line 25 to page 2, line 70	2-6,9,27

# INTERNATIONAL SEARCH REPORT

Information on patent family membe.

International application No.

**PCT/AU92/00545**

**This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.**

Patent Document Cited in Search Report			Patent Family Member		
WO	9012952	AU	55358/90		
WO	8702416	AT	42802	CN	86107092
		EP	244451	JP	63501652
				DE	3663170
				US	4781153